Guided Endodontic Access in Maxillary Molars Using Cone-beam Computed Tomography and Computer-aided Design/Computer-aided Manufacturing System: A Case Report

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Abstract

The aim of this study was to describe a guided endodontic technique that facilitates access to root canals of molars presenting with pulp calcifications. A 61-year-old woman presented to our service with pain in the upper left molar region. The second and third left molars showed signs of apical periodontitis confirmed by the cone-beam computed tomographic (CBCT) scans brought to us by the patient at the initial appointment. Conventional endodontic treatment was discontinued given the difficulty in locating the root canals. Intraoral scanning and the CBCT scans were used to plan the access to the calcified canals by means of implant planning software. Guides were fabricated through rapid prototyping and allowed for the correct orientation of a cylindrical drill used to provide access through the calcifications. Second to that, the root canals were prepared with reciprocating endodontic instruments and rested for 2 weeks with intracanal medication. Subsequently, canals were packed with gutta-percha cones using the hydraulic compression technique. Permanent restorations of the access cavities were performed. By comparing the tomographic images, the authors observed a drastic reduction of the periapical lesions as well as the absence of pain symptoms after 3 months. This condition was maintained at the 1-year follow-up. The guided endodontic technique in maxillary molars was shown to be a fast, safe, and predictable therapy and can be regarded as an excellent option for the location of calcified root canals, avoiding failures in complex cases. *(J Endod 2018;■:1–5)*

Key Words

Calcification, cone-beam computed tomography, endodontic access, intraoral scanning, prototyped guides

Significance

The guided endodontic technique in maxillary molars was shown to be fast, safe, and predictable and an excellent option for the localization of calcified root canals, avoiding failures in complex cases.

The root canal system may be partially or completely obliterated as a result of physiological aging or external aggressions, such as friction, caries, previous restorative procedures, and trauma (1, 2). Endodontic treatment is recommended when there are signs and symptoms of the presence of apical periodontitis (3).

The American Association of Endodontists has regarded the endodontic therapy of calcified root canals as having a high level of difficulty (4). Long-neck drills and ultrasonic inserts are strategies routinely used in this type of procedure. However, they still generate a high risk of failure, even when associated with visual magnification with the use of an operating microscope (5–8). Apicoectomy is another alternative for the treatment of calcified canals. Nevertheless, the location of the obliterated canal and adequate cleaning of the contaminated region after root resection are challenging, which explain why this surgical treatment is not the first choice (8).

Three-dimensional (3D) imaging may be an extremely useful tool for safer interventions, and it has become very important in all areas of dentistry, including endodontics (9, 10). In 2015, members of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology gathered to define 12 clinical situations in which cone-beam computed tomographic (CBCT) imaging would be indicated (11). In this context, CBCT imaging has been recently recommended in endodontics as a diagnostic aid in the planning and execution of root canal treatments because of its enhanced capacity to reveal the detailed morphology of the roots (12, 13) and to locate calcified root canals.

The virtual planning and guided access procedure for calcified root canals may help to preserve the tooth structure and avoid accidents such as deviations and perfo-

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rations. This may lead to an improvement in the long-term prognosis (14). In addition, guided access through root calcifications in anterior teeth has been previously performed and reported in the literature as a safe (15) and predictable technique (16).

The present case report describes 2 endodontic treatments performed in maxillary molars with the aid of CBCT imaging and 3D guides for access and location of root canals exhibiting pulp calcifications.

Case Report

A 61-year-old woman presented for treatment, reporting discomfort in the region of her left upper molars. After clinical examinations, the practitioner failed to find a pulp response to thermal and electric tests in the maxillary second and third molars although a slight sensitivity to percussion was observed. Extensive periapical bone resorptions were identified in these teeth after a CBCT scan was performed that also revealed the presence of large-sized restorations in both teeth, which was confirmed by a clinical examination. After completing the accesses under local anesthesia, the operator was not capable of immediately and safely locating the entry of the palatal canal of the second molar or that of the distobuccal canal of the third molar, confirming the calcification findings of the initial CBCT imaging.

A high-resolution, 0.12-mm voxel CBCT unit (iCAT; Imaging Sciences International, Hatfield, PA) was used to allow a more detailed view of the periapical area. The maxillary left second and third molar CBCT images showed radiolucent areas, measuring 5.88 mm and 7.92 mm, respectively (Fig. 1*A* and *B*). The root canal was only visible in the apical and middle thirds of the palatal root of the second molar and in the distobuccal root of the third molar at a distance of approximately 7.80 mm in the first and 9.04 mm in the latter from the occlusal surface to the visible light of the canal. In view of this situation, the patient was submitted to the guided access procedure in both teeth. To access the root canal lumen, a printed 3D template was used. The following steps were undertaken in order to manufacture the guide: an intraoral impression was taken and then scanned using the R700 Desktop (3Shape, Copenhagen, Denmark) and uploaded into virtual implant planning software (SimPlant Version 11; Materialise Dental, Leuven, Belgium). After the additional upload of the CBCT images, both the CBCT scan and the surface scan were matched based on radiographically visible structures (eg, the patient's teeth). The drill that was used for the guided endodontic access (Neodent SA, Curitiba, Brazil), with a total length of 20 mm, a 12-mm working length, and a 1.3-mm diameter, was virtually designed by applying the SimPlant software implant designer tool and virtually overlapped over the root canal. The axis of the drill was angled in such a way that the tip of the extended drill would reach the radiographically visible lumen of the root canal (Fig. 2*A* and *B*). After planning the position of the drill, a virtual template was designed, applying the SimPlant software template designer tool. A guiding sleeve (3.0-mm external diameter, 1.4-mm internal diameter, and 8-mm length) was customized for the drill by means of a software tool and virtually incorporated into the planning library before creating the template (Fig. 2*C* and *D*). Fixation sleeves were also created for the purpose of stabilizing the guide, preventing the perforation drill from deviating from its trajectory created based on the tomographic planning. The virtual template was exported as an STL file and sent to a 3D printer (Objet Eden 260 V with FullCure 720; Stratasys Ltd, Minneapolis, MN). The previously mentioned sleeve was integrated into the printed template to guide the drill during cavity preparation.

After the local anesthesia procedure, bone cutting was performed in 2 points under constant irrigation with saline solution for the purpose of fixating the guide in a precise manner. Having done that, guided access was obtained through the calcified root portion using the same drill at a speed of 1200 rpm (Fig. 3). Once the guide was removed, teeth were isolated using a rubber dam and a #10 K-file (Dentsply Sirona

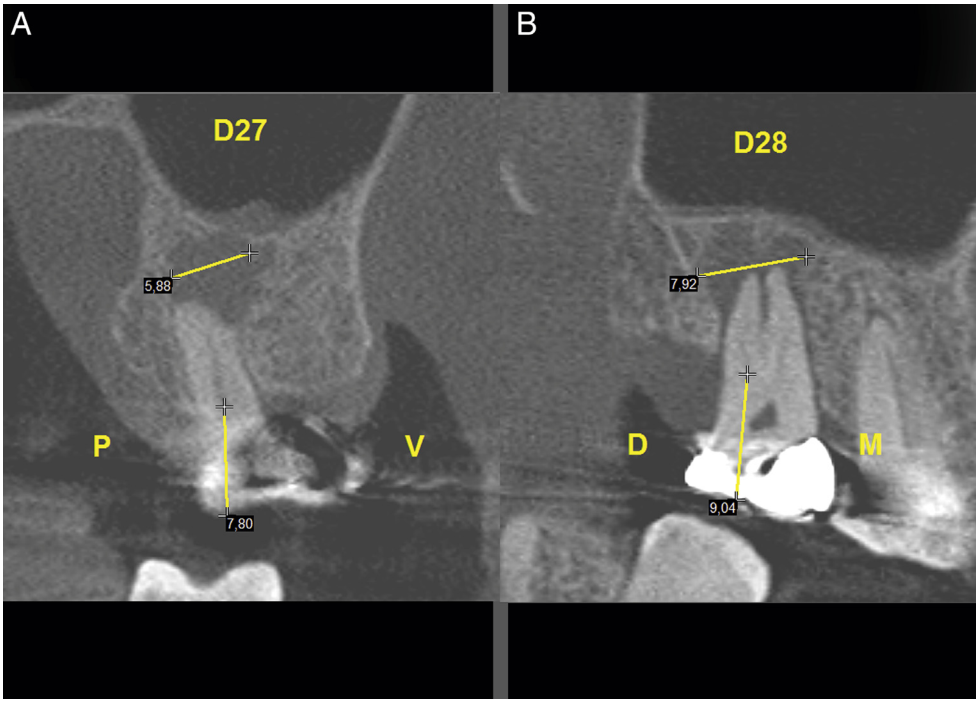

Figure 1. (*A*) A cross-sectional cut representing the palatal root of the maxillary second molar, indicating a distance of approximately 7.80 mm from the occlusal surface to the visible light of the canal and a diameter of the lesion of 5.88 mm. (*B*) A cross-sectional cut representing the distobuccal root of the maxillary third molar, indicating a distance of approximately 9.04 mm from the occlusal surface to the visible light of the canal and a diameter of the lesion of 7.92 mm.

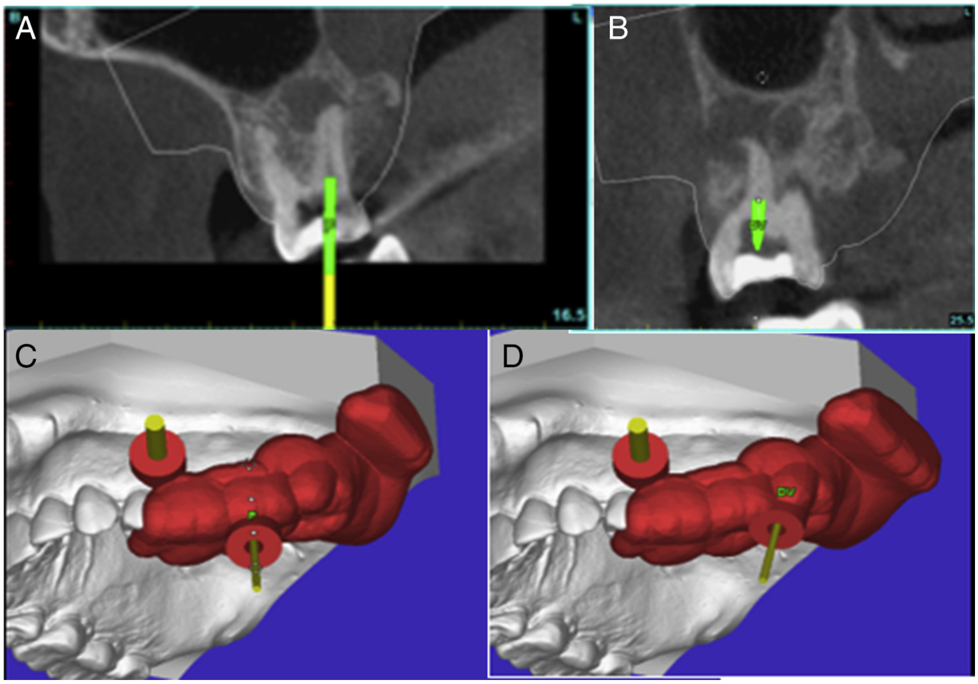

Figure 2. (*A* and *B*) A virtual drill was designed by applying the implant designer tool of the SimPlant software and virtually superimposed on the root canal of the maxillary left second and third molar. The axis of the drill was angled in such a way that the tip of the extended drill would reach the tomographically visible lumen of the root canal. (*C* and *D*) After planning the position of the drill, 2 virtual templates were designed by applying the template designer tool of the SimPlant software. Two sleeves were integrated into both of the printed templates: one to guide the drill during cavity preparation and the other to ensure correct fixation in the patient.

Endodontics, Ballaigues, Switzerland) in order to verify whether the canals had been accessed. At the same time, it was possible to verify the patency length of both canals (the palatal canal of the upper second molar and the distobuccal canal of the upper third molar) by combining the use of the apical locator (RomiApex A-15; Romidan, Kiryat Ono, Israel) with the radiographic examination. Instrumentation of both canals was performed using the WaveOne Gold Large reciprocating instrument (Dentsply Sirona Endodontics) with 2.5% sodium hypochlorite as the irrigant. After drying the canals, Calcium Hydroxide P.A. (Lenza Farm, Belo Horizonte, Minas Gerais, Brazil) and glycerin were used as intracanal medications in between treatment sessions. A composite resin–containing filler (Spectra; Dentsply Industria e Comércio Ltda, Petrópolis, Rio de Janeiro, Brazil) was used as a temporary filling. After 2 weeks, the canals were filled by the hydraulic compression technique using FM gutta-percha cones (Odous De Deus, Belo Horizonte) and an epoxy-based cement (AH Plus; DeTrey, Konstanz, Germany) as a sealer. The gutta-percha cones were adapted at 0.5 mm short of the patency length of the canals. Subsequently, the access cavities were cleaned, and the teeth were restored.

After filling the root canals of the maxillary second and third molars, the patient no longer presented pain symptoms in the region nor responded positively to the percussion tests. Three months after concluding the case, regression of the lesions was observed (Fig. 4*A* and *B*). The 1-year follow-up revealed a drastic reduction of the periradicular lesions and pain symptoms and a negative response to the percussion tests (Fig. 4*C* and *D*).

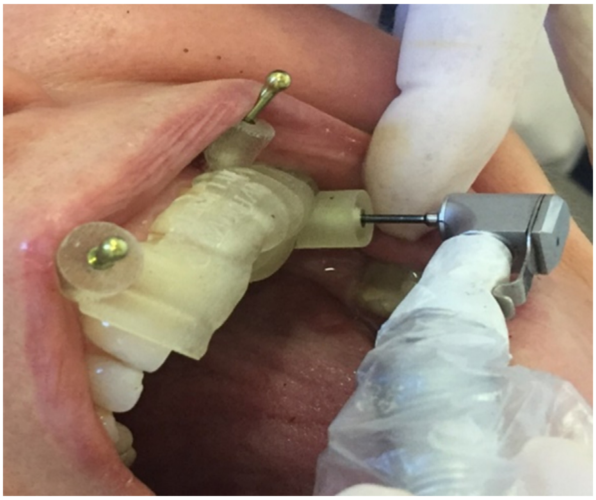

Figure 3. Access to the canal by means of the prototyped guide.

Discussion

There is an increasing number of older patients in need of endodontic treatment. These patients may present teeth with partially or completely calcified pulp chambers and obstructed root canals caused by dentin apposition throughout their lives (17–21). Young patients who may exhibit partially or completely calcified root canals as a result of dental trauma (22, 23) are another important category. Fifteen percent of traumatized permanent incisors present partial pulp obliteration; 1% became totally calcified (24), which could be considered a sign of pulp healing, and therefore a case in which endodontic treatment is not indicated (14, 15, 25). Nevertheless, there is a 1%–27% risk of these pulps becoming necrotic at some point in the future (24, 26).

The literature shows that accomplishing an adequate initial opening and identifying the entrance orifice of the canal are quite challenging when considering calcified cases added to pulp infection and usually leads to a drastic loss of dental structure associated with a greater risk of fracture and a high failure rate (14, 15).

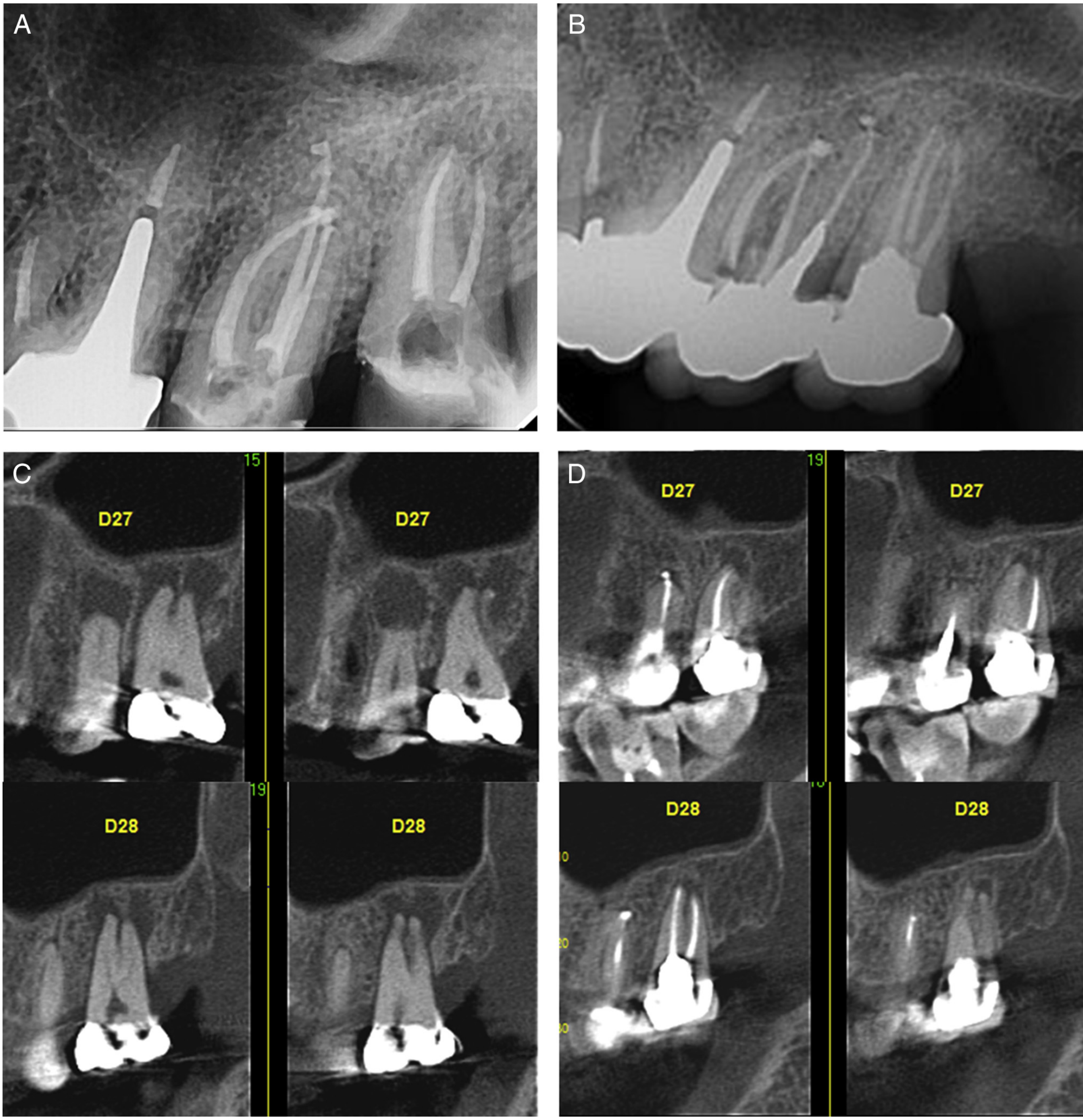

Figure 4. Case follow-up. (*A*) Radiographic image at 3 months after treatment. (*B*) Radiographic control 1 year after the procedure. (*C*) Tomographic image before endodontic treatment of teeth 27 and 28. (*D*) Tomographic image of teeth 27 and 28 1 year after endodontic treatment.

CBCT imaging has proved to be a very valuable tool in endodontics, helping with the diagnosis of periapical pathologies, root morphology, calcifications, and resorptions, among others (12, 13). Furthermore, this diagnostic technique has contributed to increasing the success rate of endodontic treatments by optimizing technical treatment planning. It is also thoroughly used in dental surgery as a planning aid together with surgical templates as a guide to bone drilling before implant placement (27, 28).

Inspired by the guided implant procedure, the guided endodontic technique consists of accessing and locating root canals with severe calcification by means of guiding templates created by tomographic planning as reported by some authors (3, 14–16, 29). This technique seems to be a safe and clinically feasible method, especially when the calcified canals could not be accessed by conventional endodontic strategies in a predictable manner (15). The procedure reduces the treatment time and can be performed by less experienced operators (16). Authors were unanimous in acknowledging the accuracy of the technique and its relevance for the new possibility of negotiating severely calcified root canals (14–16, 29). Therefore, even without the aid of an operating microscope, the guided endodontic treatment could be very helpful to professionals when facing more complex cases (14). The guiding template sleeves direct the position of the access burrs, generating greater perforation precision reproducing adequate tomographic planning (3).

It is valid to point out that this is a novel procedure and requires further research and innovation of the access drills, which should be specifically devised for endodontic purposes; thus far, reduced gauge implant surgical template fixating drills have been used (15, 16). This limitation generates changes in the original shape of the canal because of the dimension of the drills. However, an unguided location of calcified root canals could generate far greater losses of dental structure, even when the procedure is performed with an operating microscope (15).

The guided endodontic technique was also performed in lower incisors *ex vivo* using miniaturized 0.86-mm burrs that were shown to be sufficiently precise even in narrow roots. However, these same authors reported in this study that it would not be possible to perform the technique in the posterior region of the arch, in molar teeth for instance, because of the limitation of space to fit in the guide plus the access drill (29). Nevertheless, the present study showed that it was possible to perform the procedure of guided endodontic treatment in both upper second and third molars. Clinicians must take into consideration that patients with limited mouth opening might have this technique as a counterindication.

Another constraint to the guided technique would be the need to access calcified canals around curvatures because the drill should only be introduced into the straight part of the canal (29). Bearing in mind that calcifications are by and large located in the cervical and/or middle third of the canals (30) and the main curvatures usually occur in the apical thirds, this technique seems to be promising for addressing molars as well (31). In cases in which the root curvature is an absolute impediment to the safe access of the drill to the desired region, the guided surgery technique would be indicated.

A well-planned guided access technique in endodontics optimizes the time taken to perform the access step to the severely calcified canals, allows for a safer and more predictable procedure, eliminates the need for the operating microscope, and can be performed by less experienced operators (16).

Conclusion

The guided access technique for endodontic treatment of calcified upper molars was shown to be safe and accurate, facilitating access and endodontic treatment as a whole under safe, expedited, and predictable conditions. CBCT imaging and the access guide were fundamental components for performing this new technique. The simplicity of this technique allows it to be performed even by less experienced professionals. The development of more adequate drills in both length and gauge specifically designed and more capable of meeting the expectations and requirements for use in endodontics is a real need to be addressed in future works.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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